

Genes and Antisocial Behavior: Perceived versus Real Threats to Jurisprudence

*Gregory Carey and
Irving I. Gottesman*

Combine the following: medicine, ethics, jurisprudence, behavioral genetics, and antisocial behavior (ASB). Given our level of scientific knowledge today, this combination is more akin to a cerebral smorgasbord than to a dinner where starter, entree, wine, and dessert are carefully chosen to complement one another. Hence, any survey of menus must be highly selective. We accept as a given that there is a noteworthy genetic influence on ASB no matter how it is defined.¹ In terms of behavioral research, the magnitude of that genetic influence is substantial, but so is the impact from the environment, broadly defined to include pre- and post-natal, physical (e.g., anoxia, fetal alcohol syndrome, or crack) as well as psychosocial (e.g., quality of parenting, ethnic culture, or religion) elements.

We will discuss some of the major issues raised by this fact of genetic influence that have most applicability to topics usually raised by observers outside of behavioral genetics. Could one eventually use genetic information, pre-natally or post-natally, to predict who will and who will not engage in ASB? What happens if a single gene is found that contributes greatly to ASB? Does the genetic influence have implications for prevention, interventions, and rehabilitation? Do genetics play a part in race differences and ASB? We request that readers have patience with our exposition and read on.

Before proceeding, however, we must first examine the ways in which genes have been thought to relate to behavior. Here, a new paradigm is emerging and it is very helpful to recall mistakes of the past so that they are not repeated. It will be our brief that perceived threats to jurisprudence from the facts about antisocial behavior drawn from the discipline of behavioral genetics are, presently, not real (i.e., serious) threats. We note in passing that behavioral geneticists' interpretations of facts vary, and that we are considered to be middle of the road practitioners by our peers.

An Abridged History of Behavioral Genetic Research

In the early part of the 20th century, debates about genes, environment, and behavior were in the form

Gregory Carey, Ph.D., is Associate Professor in the Department of Psychology, and Faculty Fellow, Institute of Behavioral Genetics, both at the University of Colorado. His most recent book is *Human Genetics for the Social Sciences* (Sage Publications, 2005). **Irving I. Gottesman, Ph.D., Hon.FR-CPsych**, is Bernstein Professor in Adult Psychiatry, Senior Fellow in Psychology, University of Minnesota, and Sherrell J. Aston Professor of Psychology Emeritus, University of Virginia. His most recent book is *Psychiatric Genetics & Genomics* (Oxford University Press, 2004).

of Nature *versus* Nurture discussions. In the popular media, Nature (genotype) was – and sadly sometimes still is – portrayed as mutually exclusive from Nurture (psychological and physical environments), and wrongly equated with genetic determinism. Toward

ally respond to environmental events.⁶ Adaptation to stress, the formation of memory, and the very task of learning all involve genetic responses to environmental contingencies. Indeed, today one of the ways in which neuroscientists document that a certain brain region is involved in learning, memory, etc., is to measure the change in genetic activity in that region.

Could one eventually use genetic information, pre-natally or post-natally, to predict who will and who will not engage in ASB? What happens if a single gene is found that contributes greatly to ASB?

A new model has emerged, although it – like the nature/nurture and statue models – does not have a formal name. The new model views

the middle of the century, behavioral scientists came to appreciate that the “either/or” needed to be changed to a “both/and.” In a prescient presidential address to the American Psychological Association in 1953, Anne Anastasi went even further by suggesting that research needed to focus on “*how* genes interact with environments” to influence behavior.²

genes and the environment as engaging in a life-long dance. The type of dance, its movements, and its tempo change, sometimes very quickly. The lead, moreover, varies from moment to moment. We will call it the “tango” model.

The next three decades witnessed a great surge in behavioral genetics research. It was soon realized that almost all human behaviors have some genetic influences on the panorama of individual differences seen amongst us.³ Many behavioral scientists of the time viewed genes as somewhat “static” in their effects. Genes might influence a developing nervous system and then maintain that resulting system throughout the lifespan. Add some environmental stress to a certain type of nervous system and the person might develop panic disorder or depression. This is the “statue” model of genes – genes contribute to forming a statue that is then weathered by the environment.

Anastasi had it right over fifty years ago. Describing the gene-environment tango for a specific phenotype should be the goal of contemporary behavioral genetic research. We need to focus on her “*how*.”

Predictability

Thereafter, two lines of data emerged that seriously challenged the statue model. First, some very strange behaviors appeared to be heritable – amount of TV watching, divorce, age at first sexual intercourse, and combat exposure causing PTSD (nee shellshock) in Vietnam.⁴ No one seriously thought that millions of years of hominid evolution resulted in genes that programmed a nervous system to respond to a TV screen or to pick up a rifle and travel to Vietnam. Instead, researchers began to appreciate the indirect influences of genes on a distal phenotype (i.e., observed behavior). Systems of genes mediated by endophenotypes⁵ may influence activity level, for example. Individual differences in activity levels then makes it more likely that one person hikes for pleasure while another favors a sedentary lifestyle. Which of the two will watch more TV?

David Wasserman rhetorically asked “what we should do, either collectively or individually, if we could identify by genetic and family profiling the 12% of the male population likely to commit almost half the violent crime in our society.”⁷ Before attempting to answer this, we must first examine the empirical data to estimate how well we can predict in the first place.

Behavioral genetics deals with *population* statistics that have limited application to an individual person – you or your innocent/guilty client. Even some researchers lose insight into this point, so we illustrate it with a simple example. Imagine you could bet even money that men are taller than women. To check the outcome, the adult heights of 100 men and 100 women, randomly selected, are recorded and the average height of the two genders compared. How much should you wager? The scientific answer is to take out that second (or third) mortgage, cash out all your stocks and bonds, and beg and borrow as much money as you can to bet with. The odds that you will lose are one in several million.

Second, advances in molecular biology and neuroscience demonstrated that genes expressed in the brain (and virtually all other organs and systems) actu-

Now ask, who will be taller – the next man that walks into a room or the next woman? Smart money takes the man, but now how much would you wager? It should certainly be less than the previous wager – you would lose about one out of four times by picking the man, with even worse odds at a WNBA draft selection.

Means are population statistics, and we can make statements about them with a great deal of confidence.

Individuals, however, differ from their respective population means. Hence, conclusions about individuals have much less certainty to them.

One population statistic that behavioral geneticists use (and sometimes misuse) is *heritability*. The technical definition is the extent to which observed (i.e., phenotypic) individual differences can be attributed in any way to genetic individual differences. Quantitatively, heritability is a proportion; it ranges from 0 to 1.0 (or, if expressed as a percentage, from 0% to 100%). A heritability of, say, 0.4 applies to the population from which it was estimated, under the circumstances of that population's developmental history. It has very little to say about the mix of genes and environments that lead to antisocial behavior in any individual person from that population.

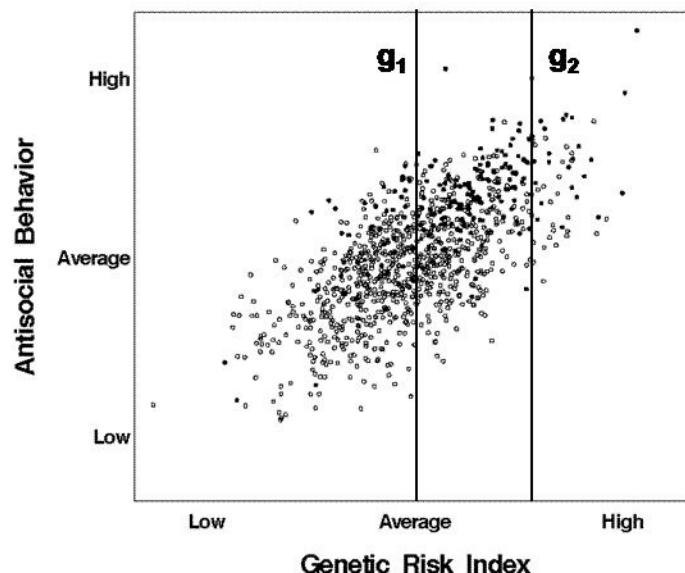
Let us now engage in a thought experiment that many consider a nightmare. Imagine a future technology in which every human gene has been cataloged, in which all those genes involving ASB have been found and their effects quantified, and in which one can very cheaply measure all of the genes in an individual person. Imagine further that we take a large number of children at birth and genotype them on the ASB-related genes. We could then assign each infant a number for its "genetic risk index" for ASB based on the data previously collected. We follow up the cohort over their lifetimes and develop a composite measure of ASB. (Since we are in thought-experiment mode, let's pretend that there are no generational changes in the environment between the original sample and the birth cohort, no measurement problems, and so on.) How well would our predictions turn out?

Surprisingly, we can answer that question with data already in hand. We do not know the genes, we cannot genotype an individual on all known genetic factors (let alone do it inexpensively), and we certainly cannot create a genetic risk index. But we can still answer the question. Why? Because we can use data on identical and fraternal twins, ordinary siblings, and adoptive relationships to calculate heritability and hence, the actual correlation between a "genetic risk index" and a phenotype, even though we cannot directly measure the former.⁸

Figure 1 illustrates the conclusions that can and cannot be made with certainty using the concept of heritability. Each dot in the figure denotes a single individual from a hypothetical population in which the heritability for antisocial behavior is .5. One can use Monte Carlo simulation (a standard statistical procedure for

Figure 1:

The predictability – and lack of it – of antisocial behavior from a hypothetical genetic risk index measured without error. Closed circles denote hypothetical individuals apprehended for a serious crime; open circles are those never apprehended.



emulating many hypothetical samples in the computer to be cost effective) to generate a genotypic value for an individual and then calculate that person's average level of antisocial behavior using the heritability estimate and a randomly generated number representing the environment. By repeating this 5,000 times, we can generate a population such as that presented in the figure.

The dots are divided into two types, open circles and gray-shaded, filled circles, although in some areas of the graph, the open circles are so numerous as to give the appearance of an amorphous black blob. The open circles denote individuals who have never come to the attention of the law, save for minor traffic violations and misdemeanors. The shaded circles are those who do come to the attention of the law. Again, these calculations were performed by simulations, assuming that the greater the average level of antisocial behavior, the greater the likelihood of apprehension for a crime. Given that many otherwise law-abiding citizens can occasionally commit and be caught for an offense, no one is entirely free of risk for arrest.

The two vertical lines labeled g_1 and g_2 in the figure portray two groups that differ in their genetic risk indices, with the open and closed circles that touch a line denoting the individuals in that group. Scientifically, we can say that the g_2 individuals will, on average, exhibit more antisocial behavior and have more contact

with the law than the g1 individuals. The certitude of this statement is quite strong, approaching that of the mean difference in height between men and women. But what can be said about a randomly selected individual from g2 compared to one from g1? Here the certitude reduces to one roughly equal to that of guessing whether a randomly chosen man will be taller than a randomly chosen woman. One should always predict that the person from g2 would have a worse outcome than the one from g1, but plenty of serious errors would be made in a large series of such comparisons.

Hence, unless the heritability is 1.0 – and the estimated heritability of ASB is much below that – we will never be able to predict without serious errors. *Brave New World* and *Gattaca* are both thought-provoking examples of science fiction; but they are a fiction that will never come to pass.

Genetic Markers

In these days of “gene for this and gene for that” discoveries, perhaps the most dreaded research result would be a “genetic marker for antisocial behavior.” Our previous discussion of heritability and predictability should have already cautioned us that any such gene would have very limited predictive effects, but caution makes for weak headlines. Undoubtedly, such news would feed the major print and broadcast media for a day or two with the expert geneticists who appear on the talk shows offering the requisite qualified statements about the importance of such a finding.

But how would such a finding impact medical and legal practice and social ethics? Should individuals with the high-risk genotype be viewed as less culpable than those with the low-risk genotype? Should such differences be considered in the penalty phase? These are usually questions sharply debated, usually with hypothetical examples. The reality of the situation is very different. We have previously gone on record to say that (1) we already have a highly replicable genetic marker for antisocial behavior; and (2) the effect of this marker is probably larger than the effect of any other marker that will ever be discovered for behavioral traits.¹⁴ Furthermore, medicine, law, and ethics have a very long history of dealing with this marker.

With very rare exceptions, individuals who receive an X chromosome from mother and another X from father are female, and those who receive an X from mother but a Y chromosome from father are male. Phenotypically, XY individuals (males) engage in eight to nine times more antisocial and criminal behavior than XX individuals (females), particularly in areas of interpersonal violence (assault, robbery, rape, and murder). Hence, the Y chromosome is a genetic marker for antisocial behavior. In fact, such a conclusion can be readily

replicated by the gold standard in genetic methodology – the family – based association design.¹⁵

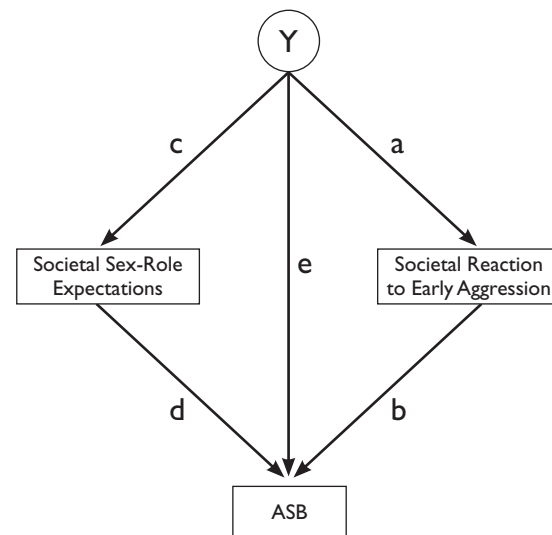
Most readers, we suspect, will respond – with various degrees of stridency – that the relationship between sex and antisocial behavior could be due to the environment. After all, could not differential socialization and tolerance of antisocial behavior be responsible for the observed sex difference? We posit that this is a very legitimate idea while steadfastly maintaining that the Y chromosome is a valid genetic marker of ASB.

Before you readers who are physicians start prescribing anti-psychotic drugs for us, we urge you to review the introduction to this paper. The Y chromosome is definitely (1) genetic; and (2) predictive of ASB. Those viewing this with the nature/nurture or statue models in mind can certainly engage in philosophical discussion about the meaning of causality here. Modern behavioral geneticists eschew such inquiries in favor of asking the following, “*how* does this relationship between the Y chromosome and ASB come about?”

Figure 2 gives a plausible, though oversimplified, picture of one such model. The Y chromosome may lead to small, initial differences in, say, aggression (path *a* in the figure), and society may react to those small differences in ways that then exacerbate the difference (path *b*). There may be few initial differences, but the traditional sex-stereotyped treatment that begins with pink and blue head caps in the nursery might extend throughout the lifespan, creating differences that otherwise would be absent (paths *c* and *d*). Finally, the cascade of hormonal differences that begins with the

Figure 2:

Hypothetical pathways illustrating the “how” of an association between the Y chromosome and antisocial behavior.



intrauterine SRY gene on the Y may indeed influence the nervous system of males and females in different ways (path *e*). Our view is that science – and eventually society at large – will benefit more from empirical research into the “how” than from arcane debates about causality.

Before leaving Figure 2, we point out that behavioral scientists consider the relationship between the Y chromosome and ASB using paths (*ab*) and (*cd*) as *mediation*.¹⁶ In short, socialization mediates the relationship between the Y chromosome and ASB. The terms *direct* relationship (path *e*) and *indirect* relationship (paths *ab* and *cd*) are also used.

The Gene

To obtain a greater appreciation of the “how,” we need to explore the meaning of a gene. When many people think of a gene and a trait, they imagine blood types – phenotypes that are relatively immutable by the environment. This also represents the view of many geneticists until the middle of the 20th century. Data from the past fifty years, however, alerted us to the great flexibility of genes and how genetic mechanisms have evolved to make us sensitive to and respond to the environment.

Most genes do not have a *direct* causal effect for anything. Instead, they remain static and unchanged in the nucleus of the cell. What a gene does is provide the blueprint for a chain of amino acids that then folds back on itself (and may join with other amino acid chains) to form a protein or enzyme. The proteins and enzymes do the actual work, not the genes.

The process whereby the blueprint of a gene is “read” to start the process of eventually building the amino acid chain is called *transcription*. For many genes, the environment can influence whether or not they are transcribed in the first place or ratchet up or down the extent to which they are already being transcribed. Environmental stress, for example, influences the expression of many genes. It initiates the transcription of some genes (colloquially known as “turning a gene on”), inhibits the transcription of others (“turning a gene off”), and changes the level of transcription of yet other genes. In short, environment plays a critical role in determining our effective genome – the extent of transcription, and the lack of it, at a given time.

Are there genes that respond to the environment with proteins and enzymes that eventually influence antisocial behavior? We have no evidence one way or the other. But there are good reasons not to discount such a possibility. Testosterone is a type of hormone that responds to the psychosocial environment in rats, mice, humans, and other primates. The effect of testosterone is to change the transcription rate of genes.

Could short-term changes in testosterone be one of many factors in a social situation that could alter the balance of proteins and enzymes to promote aggression in one circumstance or docility in another? The model of testosterone here is not one of an endogenous “aggression” machine. Instead, perhaps the social environment induces a short-term change in testosterone that then affects individual differences in the release of aggressive behaviors. The social environment is the indirect effect and testosterone is the mediator.

The “Aggression Gene” that Wasn’t

In the early 1990s, Han Brunner and colleagues were asked by members of a Dutch family to investigate why a significant number of males in the extended family engaged in peculiar behavior, including aggression and inappropriate sexual behavior. At the end of their investigation they found that affected members all carried a mutant blueprint (gene) for the enzyme monoamine oxidase A (MAO-A).¹⁷

These results (and other related ones) were portrayed in the media as the “aggression gene” and the “violence gene.”¹⁸ Many scientists – Han Brunner foremost among them – protested that there was no specificity between this gene and violence. Nevertheless, many geneticists at that time were called upon by legal counselors to request testing on the MAO-A gene for their accused or convicted clients.¹⁹

The most celebrated case of this kind was that of Stephen Mobley, who at age twenty-five shot and killed a store manager while robbing a Domino’s Pizza parlor.²⁰ Citing the Brunner study, Mobley’s attorneys petitioned the court for expert assistance and funds to be tested for the MAO-A mutation described. The intent was to present these findings during the penalty phase, and in support, the attorneys presented Mobley’s pedigree that illustrated a four-generation pattern of violence in the males. The request was denied partly because “[t]he theory of genetic connection...is not at a level of scientific acceptance that would justify its admission.”²¹

The Mobley case illustrated a stark lack of understanding of genetics on the part of the state and, possibly, on the part of the defendant’s attorneys. The observed pattern of transmission for offending in the Mobley pedigree was from grandfather to father to Stephen – i.e., male to male transmission. The MAO-A gene, however, is on the X chromosome which Stephen, being XY, could only have inherited from his mother. Hence, the pedigree was entirely inconsistent with a problem – any problem – in the MAO-A gene.²²

The MAO-A story does not end with the Mobley decision. Han Brunner himself stated that “the notion of an ‘aggression gene’ does not make sense.”²³ The members

of the Dutch pedigree had themselves clearly distinguished the affected from unaffected males. This was over forty-five years ago, well before any genetic testing for the MAO-A gene had been developed. Hence, the phenotype was quite distinct. That phenotype, however, was *not* specific to aggression. Borderline mental retardation and learning disabilities also characterized the affected males, and a century of behavioral research is consistent in showing that these features are associated with ASB.²⁴

Finally, all of the requests for genetic testing of the MAO-A mutation resulted in a singular finding – the Dutch pedigree has been the only one in the world in which this mutation has been found. Testing of many hundreds of other samples, many from convicted and incarcerated men including sexual offenders, has never uncovered even a single individual with the same defect. It is very likely that a novel mutation occurred in the MAO-A gene in this one family several generations ago and was transmitted through the unaffected women.²⁵

Today, we still lack a well-described single-gene disorder that has aggression and/or ASB as its major phenotype. Single-gene disorders typically create profound metabolic problems that influence whole systems of organs and not specific nuclei or circuits in the brain. Brunner syndrome does just that. It is a very basic metabolic defect that influences the amount of certain types of neurotransmitters in the brain. Many different behavioral systems are influenced by such a basic flaw.

Prevention, Intervention, and Rehabilitation

The first decision about preventive interventions is whether or not to engage in them in the first place. It is only recently that vitamins have been added to milk and bread, and fluoride added to our drinking water, and then with the consensus of scientists and the public. There are clear examples in genetics of well-described syndromes where withholding intervention is generally regarded as unethical (and possibly even unlawful, although we know of no established case law in this area). In phenylketonuria (PKU) a single locus recessive disorder that is 100% heritable – clearly the poster child for this situation – early detection and dietary intervention can prevent the severe mental retardation, attentional difficulties, hyperactivity and other behavioral problems that, before the middle of the 20th century, condemned a majority of its victims to institutionalization. In fact, the current ethos about neonatal genetic screening is that it should be performed only

for those disorders in which early interventions are discovered and have demonstrable ameliorative effects.

ASB is not a medical syndrome like PKU, cystic fibrosis, and sickle-cell anemia. Some might consider this fact alone as a cautionary note about intervention, but we must note that social policy has often promulgated large, extensive and expensive interventions in other complex phenotypes. Think of Head Start for example.

The real impact of the PKU lesson is in rehabilitation. If PKU can be managed environmentally, then we can never be nihilistic about environmental preventions, interventions, and rehabilitation strategies even for a complex multifactorial disease, such as schizophrenia, which has a much lower heritability. The intervention

To separate genetic factors from environmental factors in race differences requires research designs that are logically impossible at the present time.

in PKU is dramatic and outside of the ordinary dietary variation for unaffected infants and children. Hence, we must be prepared to explore interventions for ASB that are also outside of the typical environmental range. But we must never despair about those interventions because of the heritability of ASB.

A big problem with using preventative interventions is the phenomenon of gene-environment correlation (or GE correlation). GE correlation can arise in several ways. For antisocial behavior, one likely mechanism is that parents with high genetic probability of developing ASB create unsavory environments for their children after they (may) have transmitted half of the genes implicated as distal contributors to that phenotype. In ordinary epidemiological research, the observed correlation between a putative risk factor – say, parental substance abuse – and offspring, ASB is a result of the direct causal effect of parental substance abuse on offspring ASB; and the extent to which liability for ASB is transmitted to offspring and, at the same time, leads to (or is in any other way associated with) irresponsible use of alcohol and drugs. If the direct causal effect is large, then interventions into parental substance abuse will be beneficial to the offspring. If, however, most of the correlation between parental substance abuse and offspring ASB comes from the indirect GE correlation, then the effect of the intervention might be more modest.

A second mechanism can also generate GE correlation but lead to very different conclusions. People with certain predispositions can self-select preferred

environments that feel good to them. If genes influence the predisposition, and if the self-selected environment reinforces the predisposition, then the cycle of predisposition \Rightarrow environment \Rightarrow predisposition \Rightarrow etc. creates GE correlation. Unlike the familial mechanism described above, the effect of this GE correlation is confounded with the heritability of ASB. Hence, an environmental intervention into ASB could, in theory at least, have a much greater impact than a heritability estimate might suggest.

Unfortunately, with today's technology it is very difficult to quantify the magnitude of GE correlation, let alone clarify the mechanisms behind it. Only designs that can tease apart the effects of shared genes from shared environments (e.g., twins and adoptees) can begin to illuminate the issue. But even here, the strategy amounts to gathering data on, say, twins who are parents and their children, and then fitting biometrical genetic models to the data. A more superior and robust strategy – directly measuring genetic liability and correlating it with environmental risk factors – may be available at a future date.

Rather than await such a technology – which may never even materialize – the best interim approach appears to be trial-and-error. We mean no disparagement here. Interventions are being made in the home, in schools, and in the legal system all the time. We encourage rigorous academic approaches to the development and assessment of these interventions, but like all scientific enterprises, a bit of tinkering here and there should never be overlooked.

Culpability and Penalties

Would scientific genetics ever be used in the guilt phase of a trial? Given today's knowledge of genetics, the closest that one might come is when a defendant suffers from a rare genetic syndrome that has extreme mental retardation as one of its many consequences. The same, however, cannot be said of the penalty phase.

There are two distinct types of situations in which genetic evidence may be useful in sentencing. The first occurs when a defendant has a known genetic syndrome that might, in conjunction with equivocal evidence, sow doubt about the appropriateness of a harsh penalty. Imagine a convicted murderer with an IQ on the cusp of established norms for mental retardation. Would a judge accept such evidence as the defendant suffers from Fragile-X syndrome as a mitigating factor for capital punishment? We lack expertise to comment about the legal ramifications of this situation, but it certainly deserves careful consideration. The second situation is quite different. Let us return to the enzyme MAO-A, but instead of a severe defect in the gene (such as the one responsible for Brunner syndrome), imag-

ine normal variation in the gene so that some people manufacture more molecules of MAO-A than other people. Could such genetic evidence be used in a penalty phase?

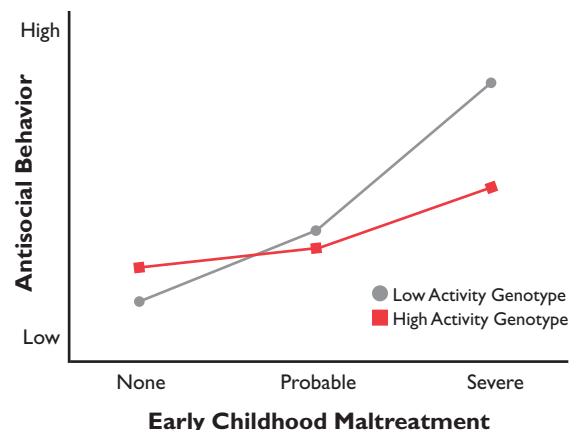
One issue that creates difficulties in thinking about these issues is genotype by environment interaction. Let us examine this briefly and then return to the discussion of culpability and penalty.

To illustrate the complexities, we discuss the concept of *genotype \times environment interaction* ($G \times E$), something that has attained the status of a sacred mantra. There are equivocal meanings to $G \times E$. The first, usually termed the lay meaning, is that both genes and the environment contribute to the phenotype. It is often expressed through phrases like "it's not the genes and it's not the environment that are important; it's the *interaction* between the two." Although this is a very useful concept for educating the public about genes and behavior, in terms of contemporary behavioral genetic science, it is a platitudinous aphorism.

The second meaning, usually termed the statistical meaning of $G \times E$, is best captured by Lindon Eaves' comment²⁶ that "all $G \times E$ interactions reflect differential sensitivity to the environment." To illustrate, examine Figure 3.²⁷ The graph plots mean levels of antisocial behavior as a function of reported childhood maltreatment. There are two lines, one for each MAO-A genotype. The genotypes do not alter the blueprint for the enzyme; rather, they influence its rate of transcription. One genotype leads to slower transcription of the DNA in the genotype and hence, a lower production rate for MAO-A molecules; the other increases transcription and leads to a higher number of MAO-A molecules.

Figure 3:

The moderating effect of low- and high-activity MAO-A genotypes on the relationship between childhood maltreatment and antisocial behavior. Based on Caspi et al., endnote 26.



The two lines in the figure reflect the two genotypes. Note that both lines demonstrate that increased childhood maltreatment leads to higher levels of ASB in both genotypes. The two lines, however, are not parallel (a fact that implies a statistical $G \times E$ interaction). The slope of the line for the low-transcription genotype is steeper than that of the high-transcription genotype. Of the two genotypes, the low-transcription one is more sensitive to childhood maltreatment than is the high-transcription genotype.

Scientists need to see such a result replicated several times before it is included in textbooks, but we can use it as a springboard for discussions on ethics and the law.²⁸ Suppose the defense attorney for a man convicted of assault and robbery argues for leniency because the man not only suffered severe childhood maltreatment, but also has the high-transcription genotype that made him most sensitive to that maltreatment. Should such arguments be considered in the penalty phase?

Race

Let's be blunt. Put the words "race" and "antisocial behavior" together in one sentence, and most people immediately think of the high arrest and incarceration rates among African Americans. Others will immediately attribute racist agendas and right wing conservatism to the authors of the sentence. The very meaning of race has become a hot issue in many fields. We have no time to enter that debate here. Simply put, we define race in the way ordinary folks use the term – the way that people self-identify themselves by, say, checking off one (or more) boxes on a census form. Genetic individual differences can indeed predict this definition of race with very high accuracy.²⁹

We view the association between race and ASB much as we did with the Y chromosome. One pathway is that race, just as the Y chromosome, leads to differential socialization, social and behavioral expectations, social identities, and a large number of other factors. These factors then influence the probability of ASB. Could genes that are associated with race directly influence ASB? We do not know. Furthermore, we posit that we currently lack the technology to provide an unequivocal answer to this question. What we can say without any qualification is that there is definitive evidence that some aspects of the social environment must be involved in this difference.

Troy Duster points out that the ratio of incarceration rates for blacks to whites was three-to-one in 1933 but increased steadily to seven-to-one in 1989.³⁰ This phenomenon is the ASB equivalent to the Flynn effect in IQ scores, i.e., the observation that mean IQ has been steadily rising in industrialized nations.³¹ These secular changes are much too large to be attributed to a

genetic phenomenon such as natural selection. Hence, their origins are most closely tied to changes in physical and psychosocial environments. The blend of law (e.g., the War on Drugs), law enforcement strategies, social factors, poverty, and overt racism that enter into the change in incarceration ratios across our nation is unknown. It is clear, however, that changes in gene frequencies due to natural selection would only have a trivial influence on this secular trend.

To separate genetic factors from environmental factors in race differences requires research designs that are logically impossible at the present time. Identical twins of opposite race are a biological impossibility (although fraternal half-sib twins of different races have been encountered). Even if we attempted a thought experiment along these lines, the results would be hopelessly confounded. If black members of twin pairs had higher rates of crime, we can never rule out the fact that society treated the black member differently from the white one. Trans-racial adoption studies are another quasi-experimental design, but there is no guarantee that the tenderness of an adoptive family is matched by the adoptee's school chums.

A body of molecular genetics findings from family-based association designs would shed considerable light on this issue. But we have no such body of knowledge, and it is unlikely to be developed in the immediate future.

These are the reasons we say that we do not know if there is a direct genetic influence on race differences in ASB and why we lack the technology to answer that question. Also, the debate about race differences is much different from academic debates such as whether anatomically modern humans interbred with Neanderthals. Among the general public, the Neanderthal question might raise a curious eyebrow here and there, but the genes-race-ASB controversy hurts, denigrates, angers, and offends people. We are not professional card-carrying ethicists. Nevertheless, we feel that common sense and common decency dictate that research, publication, and press releases addressing genetic influence on race differences should be held to a much higher ethical standard than research on Neanderthals and modern humans.³²

A Modest Suggestion

Our review suggests that there is not much in the way of firm scientific evidence on genes and ASB that is ripe for harvesting by either the legislature or the courts. Apart from rare (and usually quite debilitating) single-gene disorders and the Y chromosome – maleness – no genotype has been consistently associated with ASB. The current thinking is that any single genes that might emerge from the current epoch of molecular genetic

research will have quite small effects. Finally, even if one could assay all of the genes that could contribute to ASB and quantify each and every one of their effects, the overall error rate in predictions would be unacceptably high (see the discordance rate in identical twins for felonies in the Danish twin study by Christiansen and colleagues).³³

That said, there is no question that genetic findings will eventually be introduced (or attempt to be introduced) in court. How should these be treated? From a scientific perspective, it is important to learn from the history of DNA polymorphisms used to identify people (DNA "fingerprinting"). In the early days of such evidence, with virtually no legislation and little precedent, it was the scientists that got together to suggest a system to the court that was both fair and scientifically justified.³⁴ We suggest a strategy whereby court-appointed experts are consulted on a case-by-case basis when sets of genes with practically useful predictive power in the realm of ASB are eventually identified. The predicted effects and relevance of such genes would not be expressed "in a vacuum" and would require the best available context-relevant information about the entire life course of an individual.

Acknowledgements

We wish to thank Regents' Professor David H. Kaye, Arizona State University, for helpful critical comments on an earlier draft of this article, some of which we used.

References

1. Some of the numerous reviews in the field are: G. Carey, "Genetics and Violence," in A. J. Reiss, Jr., K. A. Miczek and J. A. Roth, eds., *Understanding and Preventing Violence*, vol. 2: *Biobehavioral Influences* (Washington, DC: National Academy Press, 1994): 21-58; G. Carey, "Human Genetics for the Social Sciences," (Thousand Oaks, CA: Sage, 2005): at 431-457; L. F. DiLalla and I. I. Gottesman, "Heterogeneity of Causes for Delinquency and Criminality: Lifespan Perspectives," *Development and Psychopathology* 1 (1989): 339-349; D. R. Miles and G. Carey, "Genetic and Environmental Architecture on Human Aggression," *Journal of Personality & Social Psychology* 72 (1997): 207-217; T. E. Moffitt, "The New Look of Behavioral Genetics in Developmental Psychopathology: Gene-Environment Interplay in Antisocial Behaviors," *Psychological Bulletin* 131 (2005): 533-554; S. H. Rhee and I. D. Waldman, "Genetic and Environmental Influences on Antisocial Behavior: A Meta-Analysis of Twin and Adoption Studies," *Psychological Bulletin* 128 (2002): 490-529; G. R. Bock and J. A. Goode, eds., *Genetics of Criminal and Antisocial Behaviour* (Chichester: Wiley, 1996); C. J. Patrick, ed., *Handbook of Psychopathy* (New York: Guilford Press, 2005).
2. A. Anastasi, "Heredity, Environment, and the Question 'How?'" *Psychological Review* 65 (1958): 197-208.
3. Carey, *supra* note 1 (2005), at 1-6; J. C. Loehlin and R. C. Nichols, *Heredity, Environment, and Personality* (Austin: University of Texas Press, 1976); E. Turkheimer and I. I. Gottesman, "Individual Differences and the Canalization of Human Behavior," *Developmental Psychology* 27 (1991): 18-22; E. Turkheimer, "Three Laws of Behavioral Genetics and what they Mean," *Current Directions in Psychological Science* 9 (2000): 160-164.
4. M. P. Dunne, N. G. Martin, D. J. Statham, W. S. Slutske, et al., "Genetic and Environmental Contributions to Variance in Age at First Sexual Intercourse," *Psychological Science* 8 (1997): 211-216; M. J. Lyons, J. Goldberg, S. A. Eisen, W. True, M. T. Tsuang, J. M. Meyer and W. G. Henderson, "Do Genes Influence Exposure to Trauma? A Twin Study of Combat," *American Journal of Medical Genetics* 48 (1993): 22-27; M. McGue and D. T. Lykken, "Genetic Influence on Risk of Divorce," *Psychological Science* 3 (1992): 368-373; R. Plomin, R. Corley, J. C. DeFries and D. W. Fulker, "Individual Differences in Television Viewing in Early Childhood: Nature as well as Nurture," *Psychological Science* 1 (1990): 371-377.
5. An *endophenotype* is an observed trait that is closer to gene action than the phenotype that is under study. See I. I. Gottesman and T. D. Gould, "The Endophenotype Concept in Psychiatry: Etymology and Strategic Intentions," *American Journal of Psychiatry* 160 (2003): 636-645. An example of an endophenotype for ASB would be resting heart rate. See A. Raine, "Biosocial Studies of Antisocial and Violent Behavior in Children and Adults: a Review," *Journal of Abnormal Child Psychology* 30 (2002): 311-326; I. D. Waldman, "Statistical Approaches to Complex Phenotypes: Evaluating Neuropsychological Endophenotypes for Attention-deficit/hyperactivity disorder," *Biological Psychiatry* 57 (2005): 1347-1356.
6. For non-technical introductions for how genes in the brain respond to stress, see Carey, *supra* note 1 (2005), at 57-60, and for how genes are involved in memory, see R. D. Fields, "Making Memories Stick," *Scientific American* (2005).
7. D. Wasserman, "Is there Value in Identifying Individual Genetic Predispositions to Violence?" *Journal of Law, Medicine & Ethics* 32 (2004): 24-33.
8. The heritability is the square of the correlation between genotypic values – read "genetic risk index" – and phenotypic values. Hence, the square root of heritability provides an estimate of the correlation. This of course, is an approximation, but science can arrive at very satisfactory approximations. Has anyone ever directly measured the distance between the earth and the moon directly with a tape measure?
9. For a non-technical introduction to PKU, see Carey, *supra* note 1 (2005), at 70-74. The American Academy of Pediatrics (AAP), the American College of Obstetricians and Gynecologists (ACOG), and the American Society of Human Genetics (ASHG), among many others provide current information about prenatal, neonatal, and postnatal genetic testing. Advances in these fields are so rapid that the web sites of these organizations should be consulted to be abreast of current knowledge.
10. P. E. Meehl, "Specific Genetic Etiology, Psychodynamics and Therapeutic Nihilism," *International Journal of Mental Health* 1 (1972): 10-27.
11. This mechanism is part of what is often termed "passive GE correlation." See R. Plomin, J. C. DeFries and J. C. Loehlin, "Gene-Environment Interaction and Correlation in the Analysis of Human Behavior," *Psychological Bulletin* 84 (1978): 309-322.
12. This mechanism is part of what is often termed "active GE correlation." See Plomin, et al., *supra* note 11, and S. Scarr and K. McCartney, "How People Make their Own Environments: A Theory of Genotype Environment Effects," *Child Development* 54 (1983): 424-435.
13. L. J. Eaves, K. Last, N. G. Martin and J. L. Jinks, "A Progressive Approach to Non-Additivity and Genotype-Environmental Covariance in the Analysis of Human Differences," *British Journal of Mathematical and Statistical Psychology* 30 (1977): 1-42.
14. G. Carey and I. I. Gottesman, "The Genetics of Antisocial Behavior: Substance versus Sound Bytes," *Politics and the Life Sciences* 15 (1996): 88-90. Carey, *supra* note 1 (2005), at 448-453.
15. Carey, *supra* note 1 (2005), at 450.
16. R. M. Baron and D. A. Kenny, "The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations," *Journal of Personality & Social Psychology* 51 (1986): 1173-1182.
17. H. G. Brunner, M. Nelen, X. O. Breakefield, H. H. Ropers and B. A. van Oost, "Abnormal Behavior Associated with a Point Mutation in the Structural Gene for Monoamine Oxidase A," *Science* 262 (1993): 578-580; H. G. Brunner, M. R. Nelen, P. van Zandvoort, N. G. Abeling, A. H. van Gennip, E. C. Wolters, M. A. Kuiper, H. H. Ropers and B. A. van Oost, "X-Linked Borderline Mental Retardation with Prominent Behavioral Disturbance:

- Phenotype, Genetic Localization, and Evidence for Disturbed Monoamine Metabolism," *American Journal of Human Genetics* 52 (1993): 1032-1039; H. G. Brunner, "MAOA Deficiency and Abnormal Behaviour: Perspectives on an Association," *Ciba Foundation Symposium* 194 (1996): 155-164; discussion 164-157
18. For example, see "Aggression Gene Found, Researchers Say," *USA Today*, March 20, 1996: 1-2; V. Morrell, "Evidence Found for a Possible 'Aggression Gene,'" *Science* 260 (1993): 1722-1723.
 19. Xandra Breakefield (personal communication), Han Brunner (personal communication), David Goldman (personal communication).
 20. *Mobley v. State*, 426 S.E. and 150 (Ga. 1993). See D. W. Denno, "Legal Implications of Genetics and Crime Research," *Ciba Foundation Symposium* 194 (1996): 248-264.
 21. M. Curriden, "His Lawyer Says it's in the Killer's Genes," *National Law Journal* 17 (1994): A12. Stephen Mobley was executed on March 1, 2005.
 22. The pedigree is reproduced in Denno, *supra* note 20, 252-253. The inconsistency was pointed out at the conference in which this pedigree was presented. See Denno, *supra* note 20, at 256.
 23. Brunner, *supra* note 17 at 161.
 24. See Brunner, *supra* 17, at 156-158 for a description of the affected phenotype in this pedigree. For reviews of the literature on intelligence, mental retardation and ASB, see J. Q. Wilson and R. J. Herrnstein, *Crime and Human Nature* (New York: Simon and Schuster, 1985): at 148-172; and R. J. Herrnstein and C. Murray, *The Bell Curve: Intelligence and Class Structure in American Life* (New York: Free Press, 1994): at 369-388.
 25. D. E. Schuback, E. L. Mulligan, K. B. Sims, E. A. Tivol, B. D. Greenberg, S. F. Chang, S. L. Yang, Y. C. Mau, C. Y. Shen, M. S. Ho, N. H. Yang, M. G. Butler, S. Fink, C. E. Schwartz, F. Berlin, X. O. Breakefield, D. L. Murphy and Y. P. Hsu, "Screen for MAOA Mutations in Target Human Groups," *American Journal of Medical Genetics* 88 (1999): 25-28.
 26. Lindon Eaves (personal communication).
 27. The figure is based on, but not identical to, Figure 1 in A. Caspi, J. McClay, T. E. Moffitt, J. Mill, J. Martin, I. W. Craig, A. Taylor and R. Poulton, "Role of Genotype in the Cycle of Violence in Maltreated Children," *Science* 297 (2002): 851-854.
 28. B. C. Haberstick, J. M. Lessem, C. J. Hopfer, A. Smolen, M. A. Ehringer, D. Timberlake and J. K. Hewitt, "Monoamine Oxidase A (MAOA) and Antisocial Behaviors in the Presence of Childhood and Adolescent Maltreatment," *American Journal of Medical Genetics, B, Neuropsychiatric Genetics* 135 (2005): 59-64 failed to replicate findings of Caspi, *supra* note 26.
 29. J. L. Mountain and N. Risch, "Assessing Genetic Contributions to Phenotypic Differences among 'Racial' and 'Ethnic' Groups," *Nature Genetics* 36 (2004): S48-53; H. Tang, T. Quertermous, B. Rodriguez, S. L. Kardina, X. Zhu, A. Brown, J. S. Pankow, M. A. Province, S. C. Hunt, E. Boerwinkle, N. J. Schork and N. J. Risch, "Genetic Structure, Self-Identified Race/Ethnicity, and Confounding in Case-Control Association Studies," *American Journal of Human Genetics* 76 (2005): 268-275 used a blind statistical clustering algorithm to assigned individuals to genetic "groups" and reported only five discrepancies to self-reported race/ethnicity among 3,636 respondents.
 30. T. Duster, "Behavioral Genetics and Explanations of the Link between Crime, Violence, and Race," in E. Parens, A. R. Chapman, and N. Press, eds., *Wrestling with Behavioral Genetics: Science, Ethics, and Public Conversation* (Baltimore: Johns Hopkins Press, 2006).
 31. J. R. Flynn, "The Mean IQ of Americans: Massive Gains 1932 to 1978," *Psychological Bulletin* 95 (1984): 29-51; J. R. Flynn, "Massive IQ Gains in 14 Nations: What IQ Tests Really Measure," *Psychological Bulletin* 101 (1987): 171-191.
 32. See J. C. Loehlin, "Should we do Research on Race Differences in Intelligence?" *Intelligence* 16 (1992): 1-4. For a viewpoint on presenting results on genetics and race differences as applied to IQ. We are unaware of any similar published views on presenting research on genes, race, and ASB.
 33. Carey, *supra* note 1 (2005), at 435.
 34. E. S. Lander and B. Budowle, "DNA Fingerprinting Dispute laid to Rest," *Nature* 371 (1994): 735-738.